

# Patterns of CO<sub>2</sub> variability from AIRS data

Alexander Ruzmaikin & George Aumann

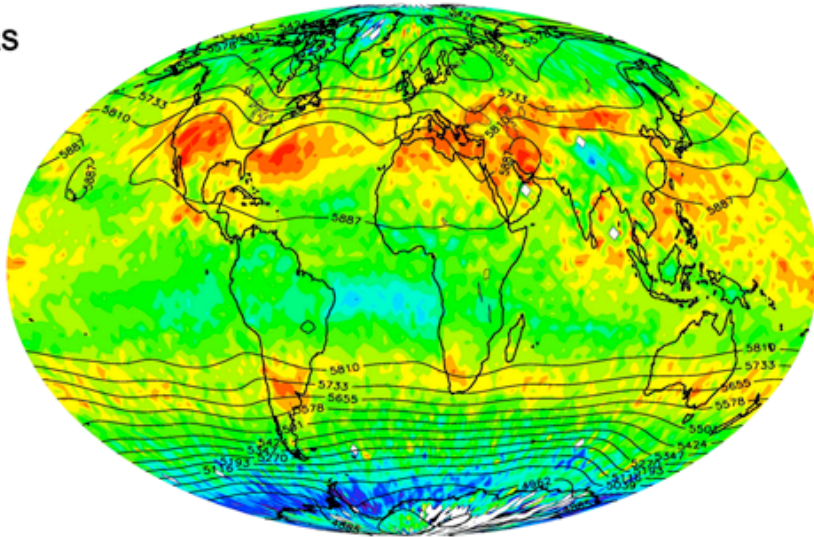
in collaboration and discussions with

Steve Licata, Jan Gohlke, Tom Pagano, Ed Olson,  
Mous Chahine and Yuk Yung

Jet Propulsion Laboratory, California Institute of Technology

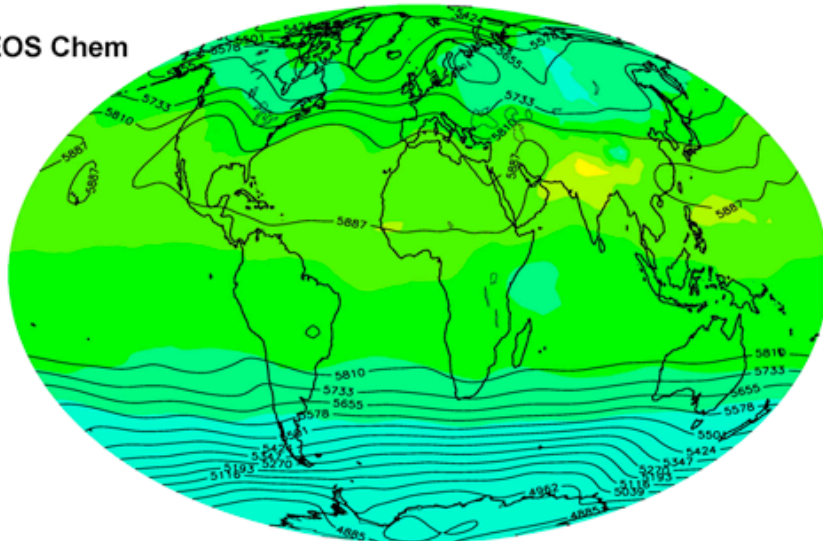
# Motivation

AIRS



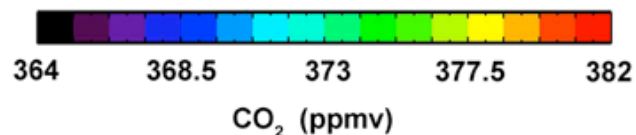
- ✧ AIRS provides almost 8-year long global CO<sub>2</sub> concentration in mid-troposphere (Chahine et al. 2008)

GEOS Chem



- ✧ Currently the AIRS CO<sub>2</sub> distribution is not reproduced by models

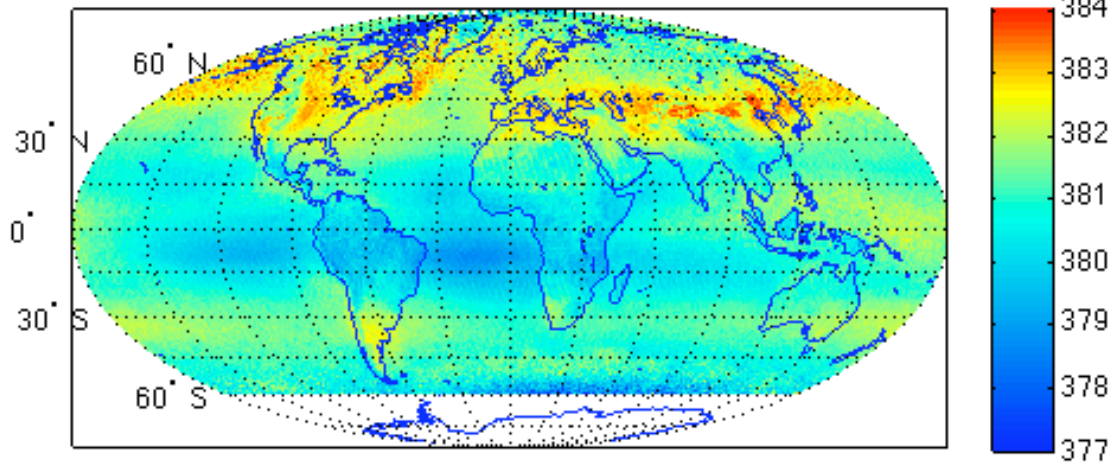
- ✧ Try pattern recognition techniques



# Approach: Data & Methods

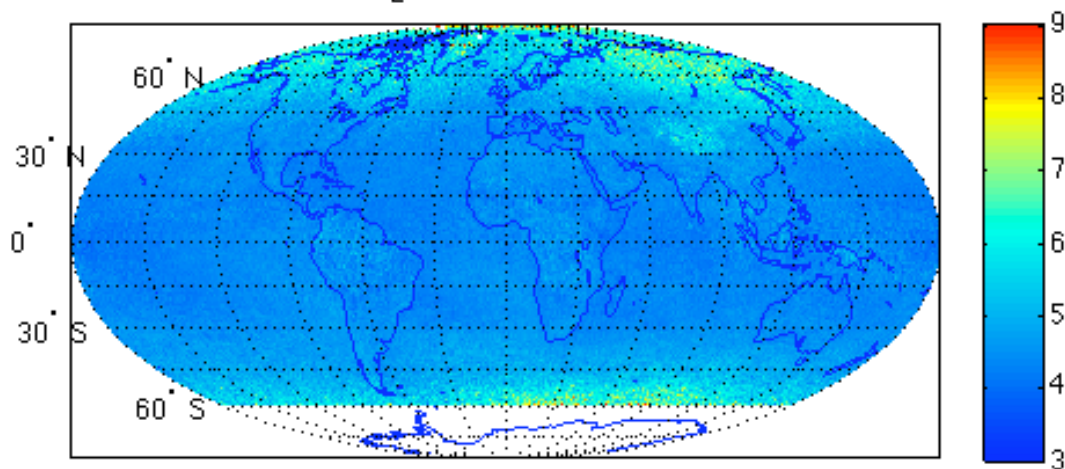
- We examine the global 7-year long (2003-2009) mid-tropospheric CO<sub>2</sub> retrievals obtained from the measurements by the Atmospheric Infrared Sounder (AIRS) and its companion instrument, the Advanced Microwave Sounding Unit (AMSU), onboard of Aqua spacecraft. The data are L2 monthly means on a 1° x 1° grid and L3 on 2° x 2.5° grid.
- The Spatial patterns and their time variability are evaluated using Principal Component Analysis (PCA). We also probing 2D Empirical Mode Decomposition.

Mean, CO<sub>2</sub>, AIRS L2 ( $1^0 \times 1^0$ )



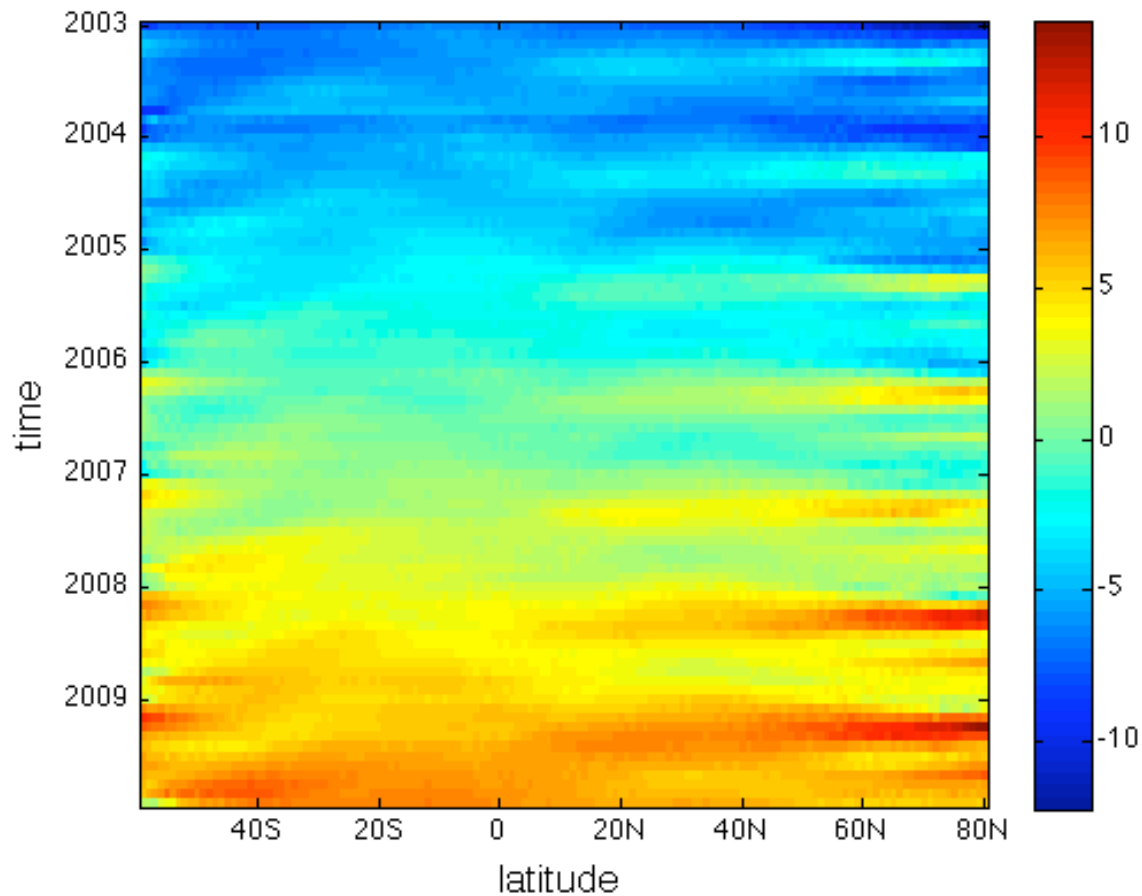
## Mean and STD in Each Pixel

STD, CO<sub>2</sub>, AIRS L2 ( $1^0 \times 1^0$ )



- Does not take into account correlations between pixels
- Time variability is lost

# Evolution of Zonal Mean



- Not easy to interpret due to NS asymmetric time variability

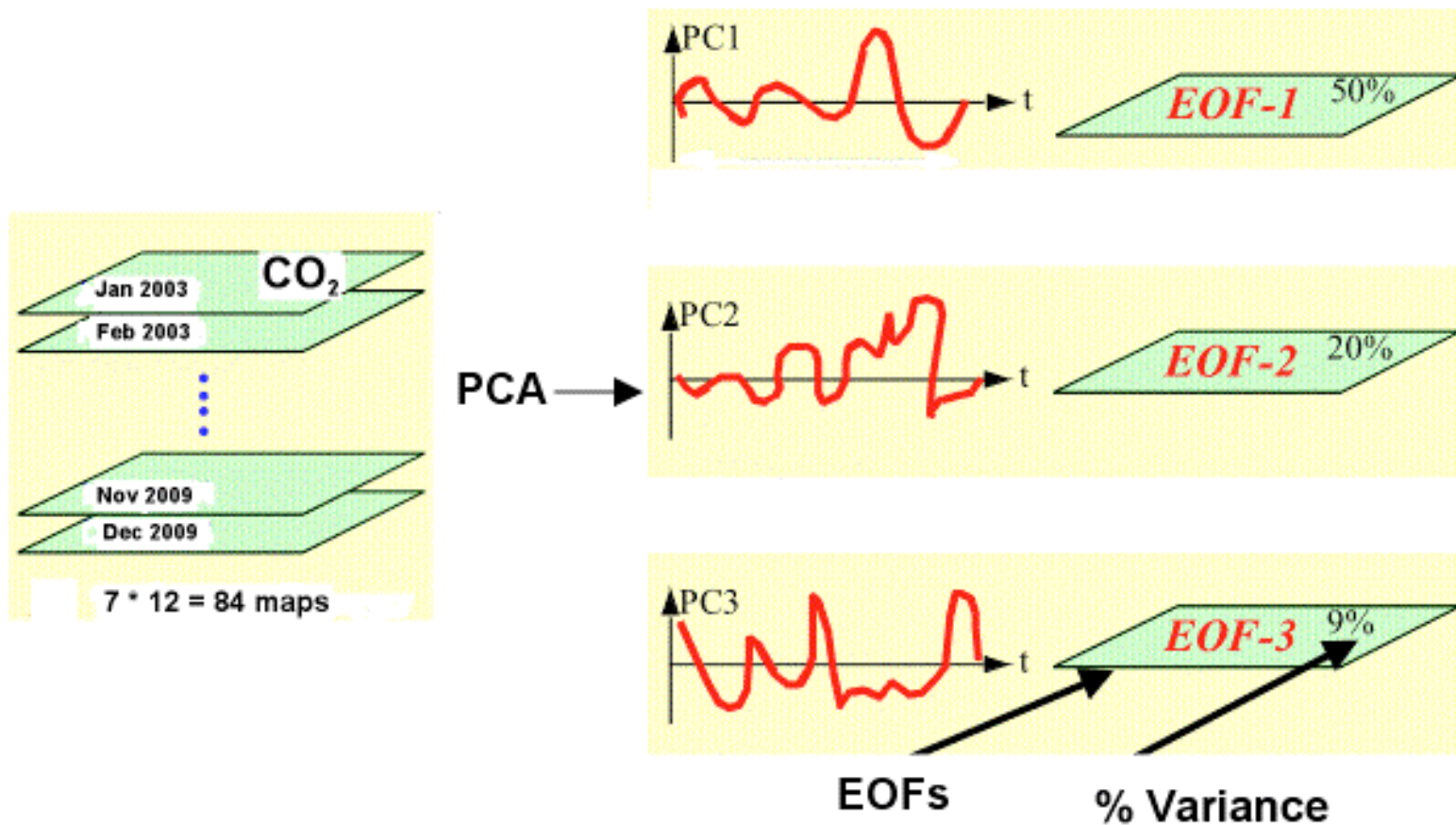
# Principal Component Analysis (PCA)

$$\text{CO}_2(x, y, t) = \langle \text{CO}_2(x, y) \rangle + \sum_k \text{PC}_k(t) \text{EOF}_k(x, y),$$

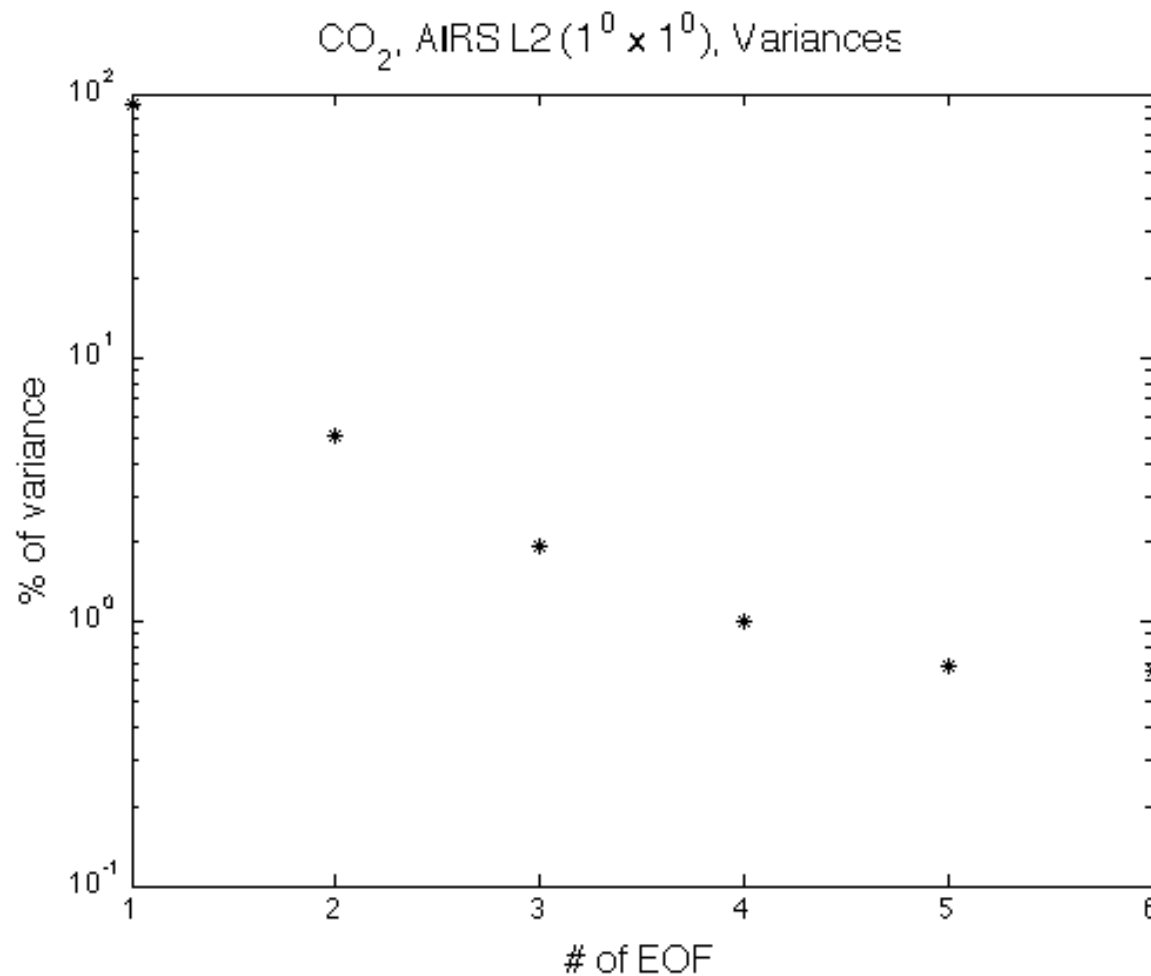
where  $\langle \text{CO}_2 \rangle$  is the time mean and the sum refers to anomalies.

To calculate EOFs, their variances, and PCs we use SVD code in Matlab.

# What do we get from PCA?

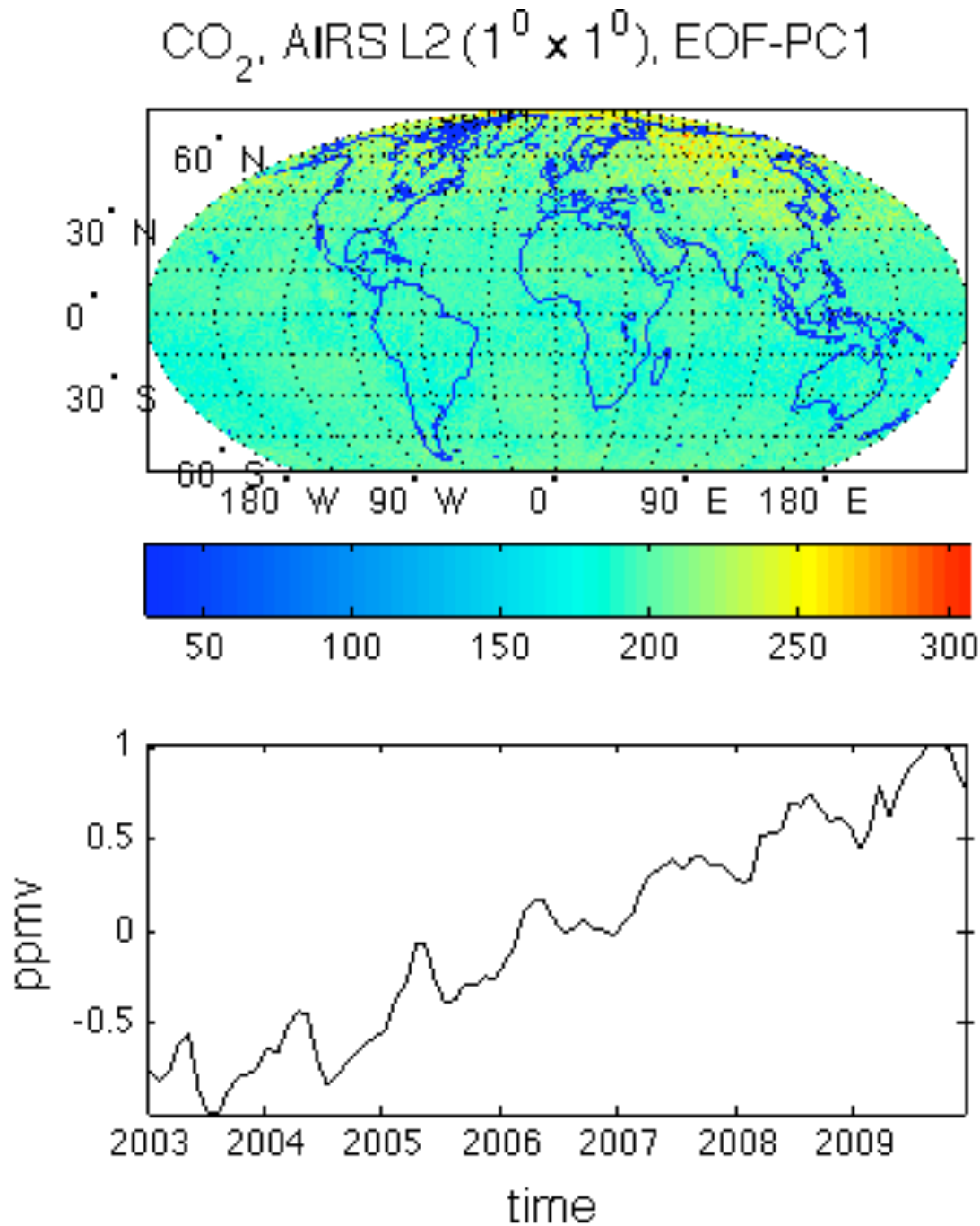


# % of Variance Explained by Each EOF



$$\lambda_1 = 92.2\%, \quad \lambda_2 = 3.5\%, \quad \lambda_3 = 2.0\%, \quad \dots$$

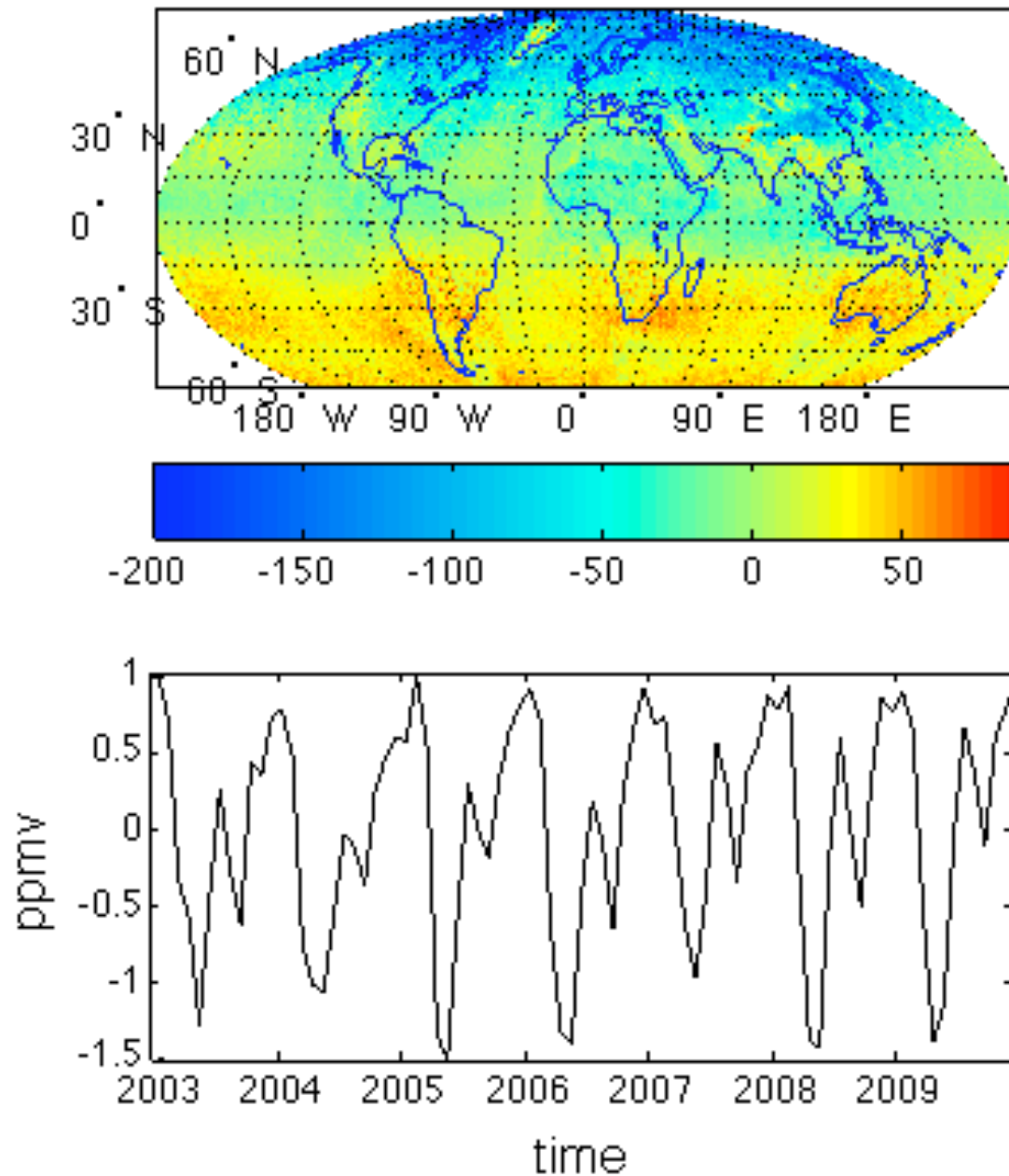
# First EOF & PC



Trend Pattern

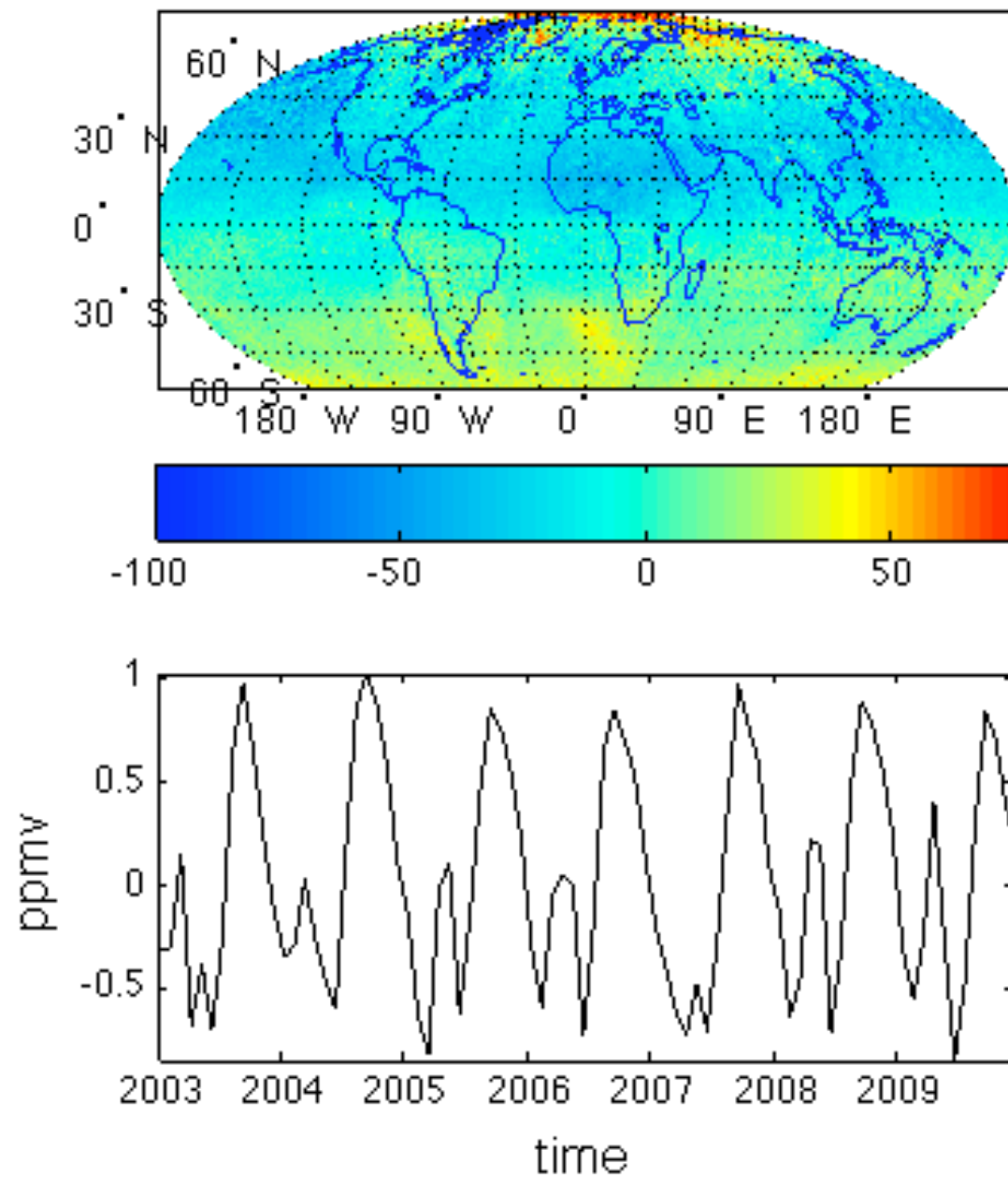
## Second EOF & PC

CO<sub>2</sub>, AIRS L2 (1<sup>0</sup> x 1<sup>0</sup>), EOF-PC2



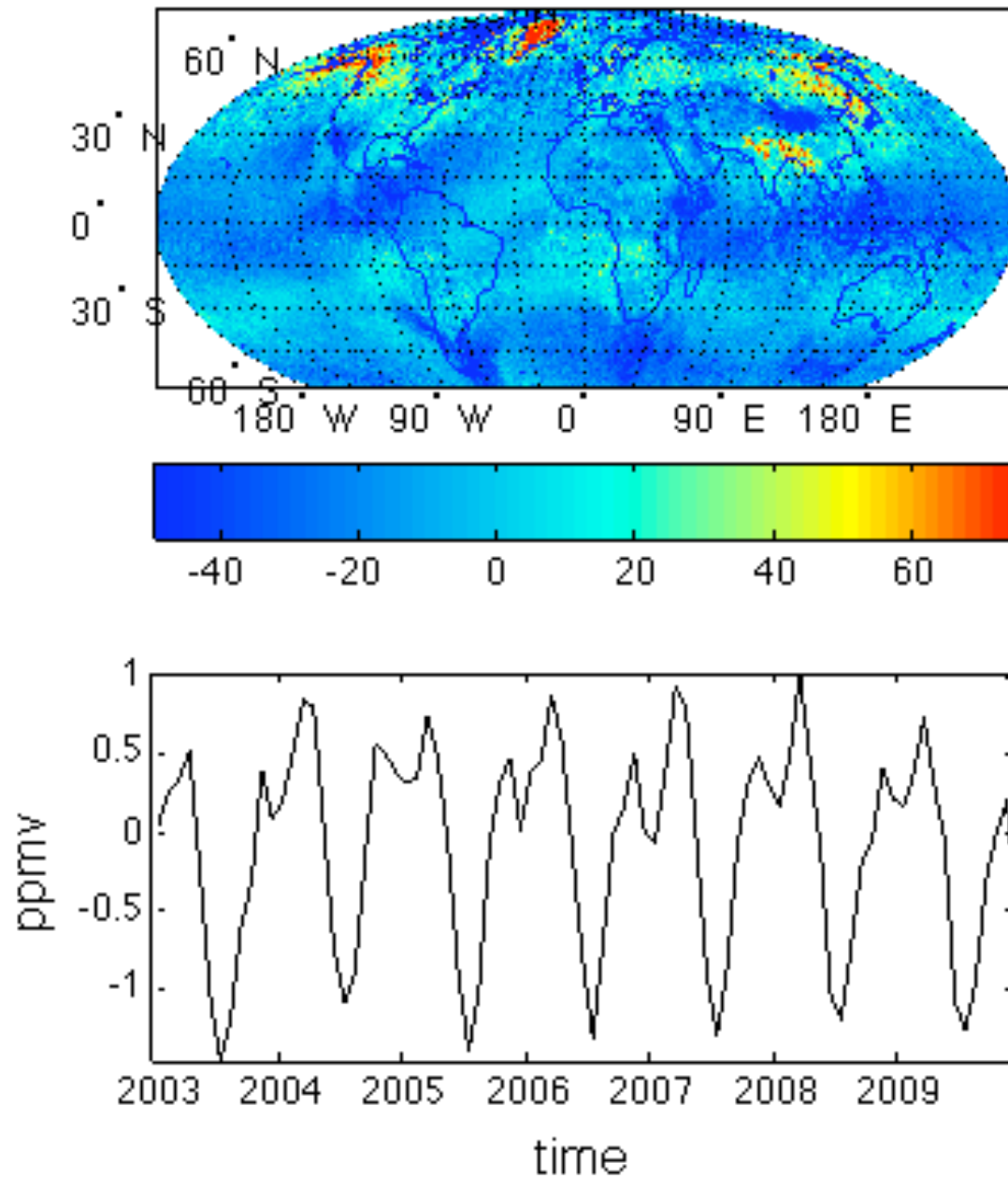
# Third EOF & PC

CO<sub>2</sub>, AIRS L2 (1° × 1°), EOF-PC3

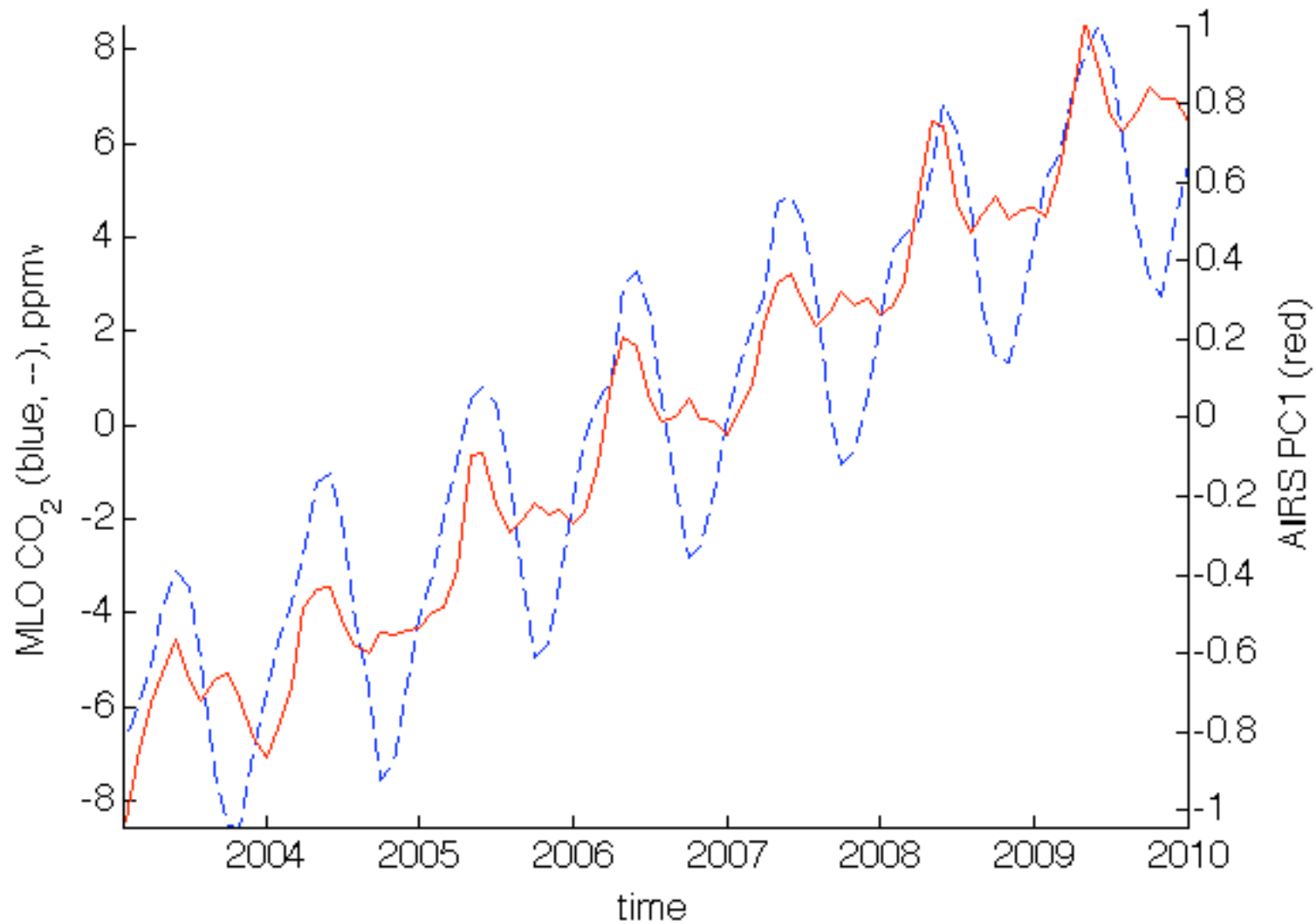


# Fourth EOF & PC

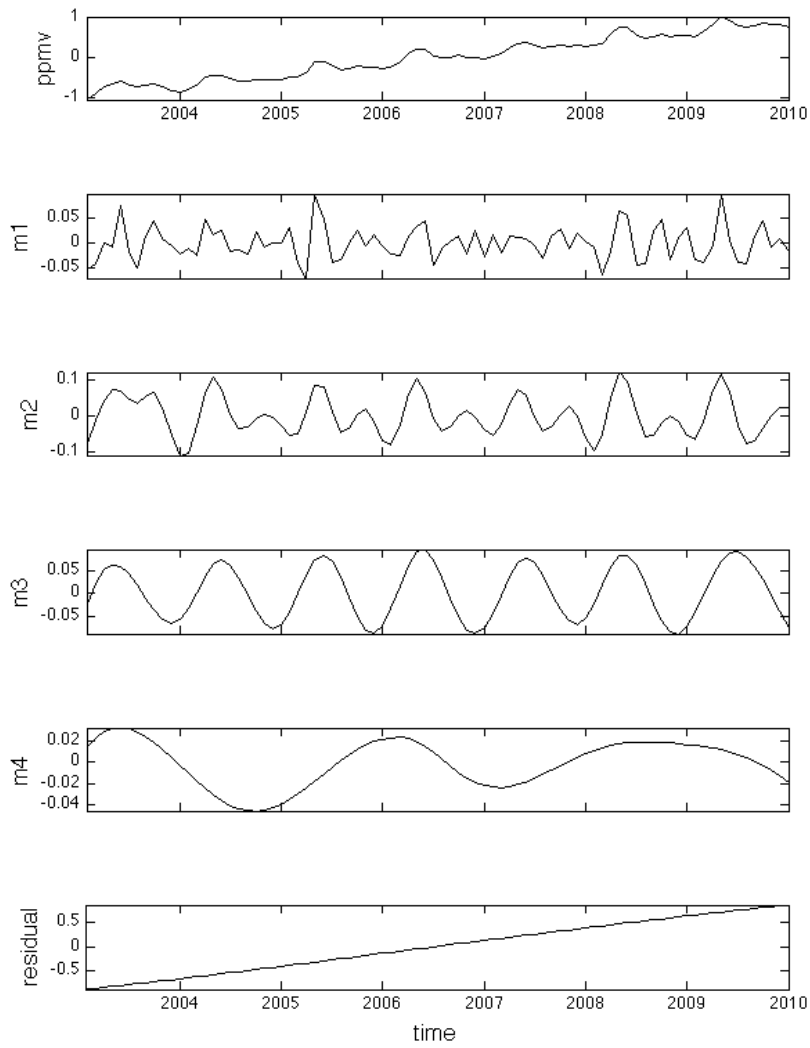
CO<sub>2</sub>, AIRS L2 (1<sup>0</sup> × 1<sup>0</sup>), EOF-PC4



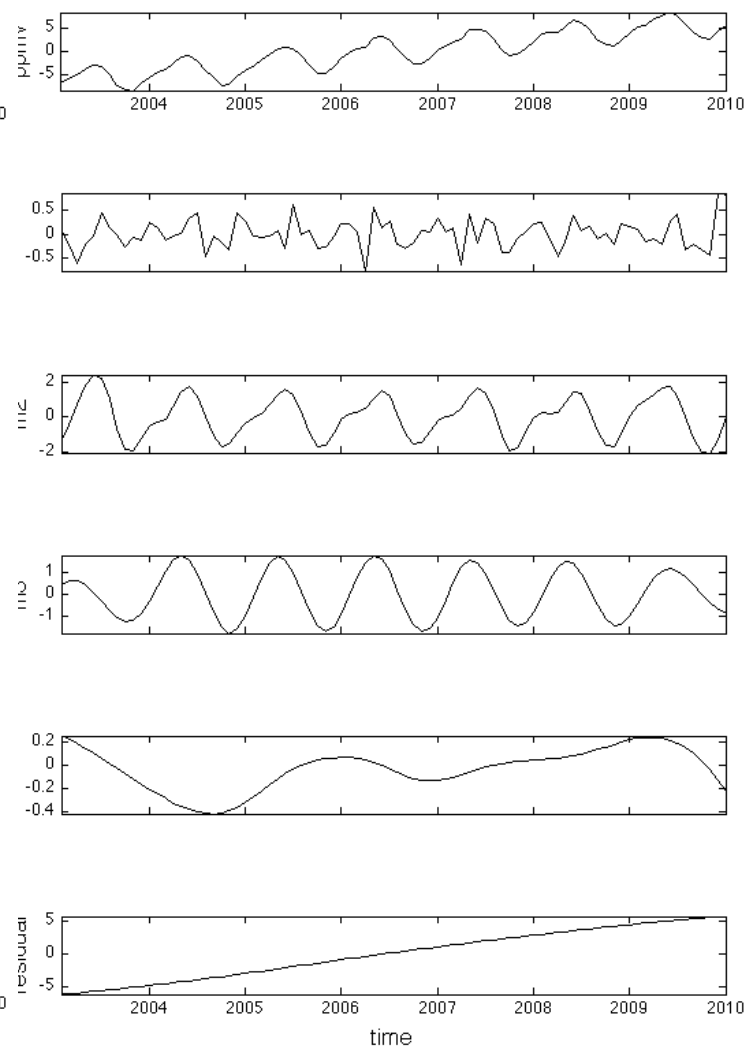
# PC1 and Mauna Loa Record



# AIRS PC1



# MLO



data

noise

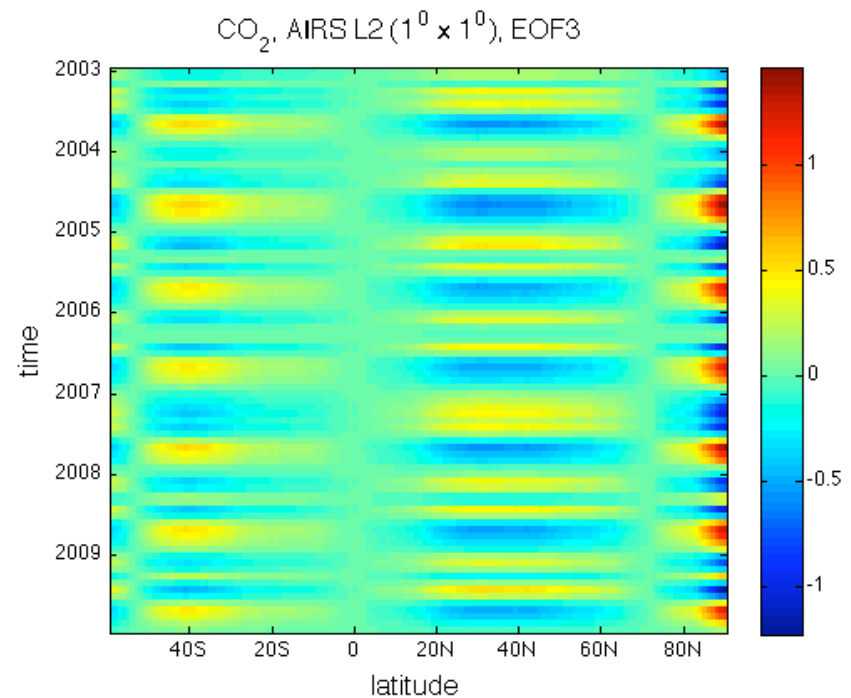
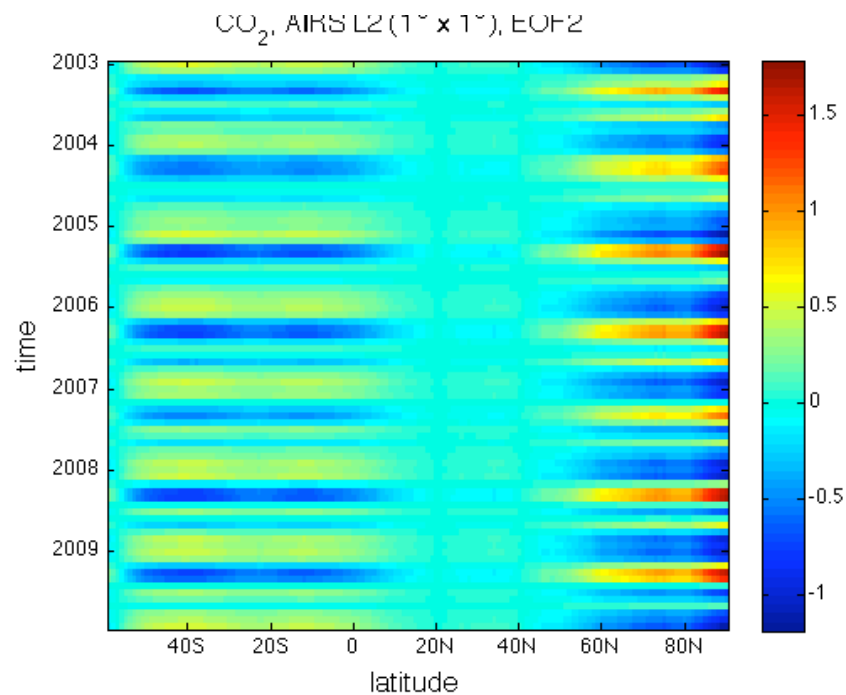
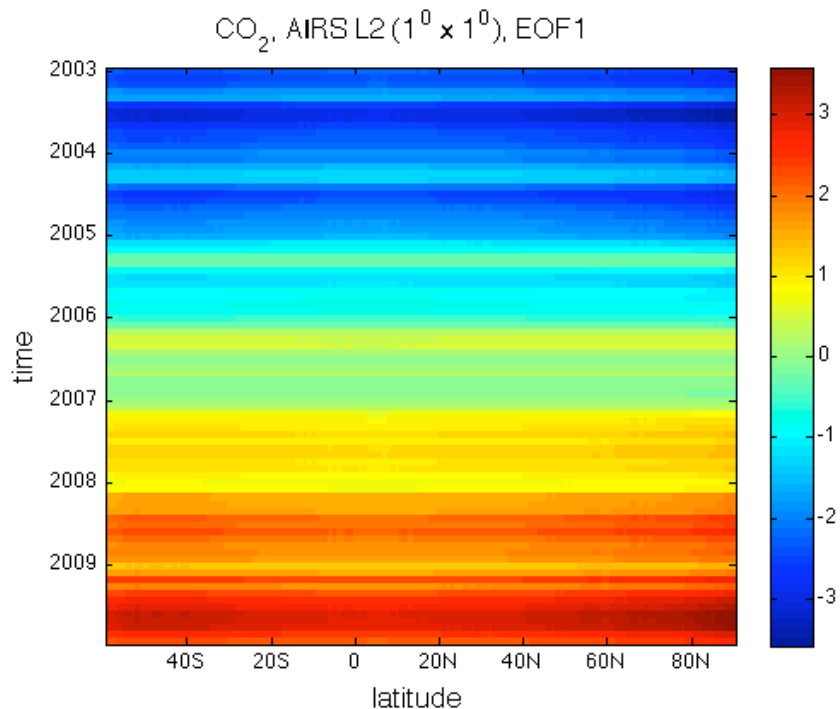
semi-annual

annual

Nino range

trend

# Evolution of Zonal Means for First EOFs



# Preliminary Conclusions

- ❖ Major structure (first EOF) explains more than 92% of variance and trend
- ❖ MLO site closely reflects the variability of the major structure
- ❖ The other structures (next EOFs) show annual and semi-annual variability
- ❖ The third EOF shows a pattern in Southern hemisphere seen at specific times by Chahine et al. (2008)
- ❖ Causes of structures are under investigation

# References

- Chahine, M. T., L. Chen, P. Dimotakis, X. Jiang, Q. Li, E. T. Olson, T. Pagano, J. Randerson and Y. Yung (2008), Satellite remote sensing of mid-tropospheric CO<sub>2</sub>, Geophys.Res. Let., 35, L17807, doi:10.1029/2008GRL035022.
- Preisendorfer, R. W. (2007), Principal Component Analyses in Meteorology and Oceanography, Elsevier Pbls.
- Huang, N. E. and Z. Wu, Review on Hilbert-Huang Transform, Reviews of Geophysics, 46, 1, 2008.